CALIFORNIA DIVISION OF MINES AND GEOLOGY

FAULT EVALUATION REPORT FER-165

Los Alamos Fault

Santa Barbara County, California

by

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INTRODUCTION

The Los Alamos fault lies at the eastern end of Los Alamos Valley, Santa Barbara County, in the Zaca Creek 7.5' quadrangle (see Figures 1A & B). The fault is inferred to extend westward into the Los Alamos and Sisquoc quadrangles, and southeastward into the Los Olivos quadrangle. Numerous earthquakes occurred in Los Alamos Valley in 1902 and 1915, with a maximum estimated Richter magnitude of 5.5 (Toppozada and others, 1978, p. 14, 17). The epicentral area of the 11 January 1915 earthquake, as determined by Beal (1915), lies approximately 4 km east of Los Alamos, close to the Los Alamos fault (see Figure 2). The purpose of this study is to determine which, if any, segments of the Los Alamos fault meet the criteria of "sufficiently active and well defined" necessary for zoning under the Alquist-Priolo Special Studies Zones Act (see Hart, 1980, p. 5-6).

SUMMARY OF AVAILABLE DATA

The Los Alamos fault is a low-angle (8° - 40°) reverse fault (northeast side down) which displaces the Paso Robles Fm. (Plio-Pleistocene), Orcutt Sand (Pleistocene), and "older terrace deposits" (late Pleistocene; see the summary of Guptill and others, 1981, below). The name was first applied by Sylvester and Darrow (1979). The surface fault trace is best defined northeast of, and parallel to, U.S. Highway 101 at the eastern end of Los Alamos Valley. The trace is 3.8 km long, and trends south-southeast from near Alisos Canyon Road to the eastern border of sec. 1, T. 7 N., R. 32 W., S.B.B.M. (see Figures 2 and 3). The fault is difficult to follow as a surface feature to the west and southeast.

Arnold and Anderson (1907) produced the first geologic map of the region, as part of a study of the Santa Maria oil fields. They did not recognize the Los Alamos fault, but they did map a fault on trend with it to the west in the hills south of Los Alamos Valley (Figure 2). This fault, in Canada Laguna Seca, is reported as having several hundred feet of displacement (north side down) in the Paso Robles Formation (upper Miocene-Pleistocene "Fernando Fm." of Arnold and Anderson, 1907, p. 85). In their cross-section F-F (Plate VII), they infer the fault to be vertical. They indicate on Plate I that Pleistocene terrace deposits are offset in Canada Laguna Seca, although evidence for this could not be verified on the air photos.

Beal (1915, Figure 2 and p. 18) suggested that an eastward projection of the fault mapped by Arnold and Anderson was responsible for the 11 January 1915 earthquake. Beal did not find any evidence of fault rupture during his nine days of field work. He considered the Confaglia Ranch (see Figure 2, this report) to be the epicenter, based upon isoseismal data he collected during his trip. Beal's map is a small-scale sketch map, and the fault location on Figure 2 of this report is necessarily generalized. No evidence was seen by this writer on available air photos to support Beal's hypothesis of a continuation of the fault eastward through the hills to Los Alamos Valley.

Woodring and Bramlette (1950, Plate I) mapped the Los Alamos area as part of a larger study of the Santa Maria district. They show the (unnamed) Los Alamos fault extending from the axis of the Los Alamos syncline at Alisos Canyon Road, southeastward along or close by the fault trace mapped by Guptill and others (1981), then continuing across U.S. 101 to the eastern edge of their map (Figure 2). They also show the Los Alamos fault in cross section to be vertical, and to die out at depth in the Sisquoc Fm., along the axis of the Los Alamos syncline. The fault is interpreted as having a maximum displacement (northeast side down) of approximately 150 m in Paso Robles Fm. [late Pliocene and Pleistocene (?)], with smaller offsets in the underlying Careaga Fm., Foxen Fm., and Sisquoc Fm. Locally, the fault is shown to offset Holocene alluvium (Figure 2), but faulting in the alluvium could not be verified by this writer. They did not extend the Los Alamos syncline axis along the northeast side of U.S. 101.

A second fault is mapped by Woodring and Bramlette as trending S 62° E (south side down), across Canada Laguna Seca (Figure 2). The fault is shown as displacing Paso Robles Formation in Canada Laguna Seca, and displacing Holocene alluvium in Los Alamos Valley west of Canada Laguna Seca. They did not map Pleistocene terrace deposits or Holocene alluvium in Canada Laguna Seca. Unless significant changes in direction of strike and sense of displacement occur east of Canada Laguna Seca, this fault would not be an extension of the Los Alamos fault. They do not show deposits of late Quaternary alluvium in Canada Laguna Seca, as was mapped by Arnold and Anderson (1907). No evidence was seen by this writer on available air photos of an eastward extension of this fault through the hills to Los Alamos Valley, or of displacement in the Holocene alluvium at the west end of this fault.

Dibblee (1950, Plates 1 and 2) did not map either the Los Alamos fault or the fault in Canada Laguna Seca. He did map a syncline whose axis is partly coincidental with the Los Alamos fault (Figure 2).

Sylvester and Darrow (1979, p. 393-394) suggested that the Los Alamos fault is a segment of one of several west- or northwest-trending faults in the Santa Maria basin that branch from the Santa Ynez fault near Lake Cachuma. They infer that the Los Alamos fault is linked in the subsurface with the Baseline fault to the southeast, and with the Casmalia and Pezzoni faults to the northwest, based upon similar trends and sense of displacement on the faults. Their maps also show the Los Alamos fault to connect with the north-trending fault in the West Cat Canyon oil field, but do not describe the connection. They note that, based upon unspecified geomorphic evidence, Ziony and others (1974) classify the Los Alamos fault as Holocene. [The fault locations shown by Sylvester and Darrow are generalized and were not evaluated; no evidence other than published oil field mapping was cited by them for the connecting faults. The faults mapped by Woodring and Bramlette (1950) in the Orcutt and Cat Canyon oil fields and Solomon Canyon area are not evaluated in this report. These faults will be evaluated in another FER.]

The major study concerning the Los Alamos fault is that of Guptill and others (1981). Lineaments and Quaternary terrace units were mapped on low-sun-angle air photos, several suspected faults were field-checked, and trenches and test pits were excavated along the trace of the Los Alamos fault near Barham Ranch (Figure 2). They found geomorphic evidence of late Pleistocene and possibly Holocene surface faulting along the Los Alamos and Baseline faults (scarps and closed depressions), and exposed the Los Alamos fault in two of their trenches (see Figure 2). However, they did not find conclusive evidence of Holocene faulting, such as young scarps or offsets of young geomorphic features.

Three trenches and three test pits were dug along the Los Alamos fault by Guptill and others. [The trenches and test pits are mislocated in their Figure 3; see Figure 3 of this report for correct locations.] The fault zone was exposed in Trenches 1 and 2, and consists of a series of low-angle (8°-40°), southwest-dipping, reverse faults. Slickensides on the fault planes indicate pure dip-slip. The fault planes typically have a shallow dip near the surface, steepening to 30°-40° near the trench bottoms. The test pits were dug in closed depressions along the fault to obtain datable material for age determinations, but none was found.

In Trench 1, a 31-meter wide zone containing six separate faults was exposed. Most of the faults dipped between 10° and 40° southwestward, and had a reverse sense of displacement (Figure 4), although one fault showed a minor right-lateral component, and another fault had a normal sense of displacement. Dip-slip displacement is a minimum of 7.62 meters on the main (northeast) strand, where Paso Robles Fm. (Plio-Pleistocene) is thrust over a late Pleistocene terrace unit. Near the ground surface, the main strand has displaced the base of the 'A' soil horizon 75 cm (30"). The main strand is coincident with a low break in slope at the base of the scarp, which Guptill and others believe supports the idea of recent fault rupture. Although a soils morphologist was not present at the trench, the degree of soil development in the faulted 'A' horizon indicates a Holocene or latest Pleistocene age for most recent surface rupture (P. Guptill, 1985, personal communication). [Based upon examinations of the trench log and unit descriptons, G. Borchardt (1985, personal communication) believes that the age of the youngest soil may be as young as 1000 years.] Dip-slip displacement of the Paso Robles Fm. on the normal fault (adjacent to and west of the main strand) is a minimum of 2.75 meters. The other faults, upslope from the main and secondary strands, showed dip slip displacement within the Paso Robles Fm. of between 18 cm and 55 cm.

Trench 2 was excavated across the base of the fault scarp and through a sag pond. The trench exposed two main fault strands and several small shears in Orcutt Sand (middle Pleistocene) uphill from the sag pond. Sense of displacement on the two faults is reverse slip, with 6 cm of displacement within the Orcutt Sand on the north strand and 46 cm displacement on the south strand. The base of the 'B' soil horizon is offset 25 cm on one of the faults. [No age estimate for the 'B' horizon was given by Guptill and others. G. Borchardt (1985, personal communication) believes that the age of the 'B' horizon may be as young as 10,000-15,000 years.] The shears are much less prominent [and fewer in number], which Guptill and others believe indicates that recent faulting dies out to the east.

Trench 3 was excavated across a break in slope higher on the scarp and south of Trench 1. This trench exposed only the depositional contact of a late Pleistocene terrace unit on Paso Robles Fm.

Evidence cited by Guptill and others (1981, p. 29) supporting a connection of the Los Alamos and Baseline faults includes the following items:

1) Both faults have a similar style of faulting: dip-slip, north or northeast side down.
2) Weak lineament trends extend from the Baseline fault northwestward through Los Olivos to the Los Alamos fault.
3) The Orcutt Sand (middle Pleistocene) is divided by Guptill and others into two sub units - Q2a and Q2b. Unit Q2a is topographically higher than Q2b and is found only southeast of the projected fault. The difference in elevation is consistant with reverse faulting.

The location of the connecting fault, as shown in Figure 2 of this report, is completely inferred northwest of the Baseline fault (P. Guptill, 1985, personal communication).

Although a northwestern extension of the Los Alamos fault has been proposed, Guptill and others prefer an extension (concealed by alluvium) along the south margin of Los Alamos Valley (see Figure 2). This extension is supported by an alignment of north-facing low knolls in the Paso Robles Fm. on the south margin, which would represent the proper sense of displacement on the fault. The knolls are on the north flank of a west-trending overturned anticline immediately south of and parallel to the Los Alamos syncline. The youngest unit overturned is the Paso Robles Fm. Guptill and others note that near Los Alamos, bedding in the Paso Robles Fm. usually is gently dipping (0°-30°), so the overturned anticline is severe local deformation that may be fault-related. In addition they found south-dipping shears in the Paso Robles Fm. south of Los Alamos, and mention the reverse fault (northside down) of Arnold and Anderson (1907) in Canada Laguna Seca. [See the discussions of Woodring and Bramlette (1950), and Arnold and Anderson (1907), above. Guptill and others do not identify the locations of shears in the Paso Robles Fm., nor do they show the fault of Arnold and Anderson in their Figure 1. They show the fault in Canada Laguna Seca mapped by Woodring and Bramlette but do not mention it in their report.]

INTERPRETATION OF AIR PHOTOS AND FIELD OBSERVATIONS

Two sets of black and white aerial photographs were available to this writer: 1) U.S.D.A. series BTM, 1954, scale 1:20,000; and 2) Low-sun-angle photographs (10° and 15° to the sun), scale 1:24,000(?), which were flown in October 1979 for the study described by Guptill and others (1981).

Reverse movement along the Los Alamos fault has formed a curvilinear northeast-facing scarp which extends 3.8 km southeastward from the old Confaglia ranch house to San Antonio Creek (see Figure 3). The upthrown (southwest) block is at the base of the southwest-dipping flank of the Solomon Hills. Evidence of recent faulting includes the constriction of drainage in Canada del Comasa, and alignment of linear drainages, saddles, closed depressions and linear trenches along the northeast side of the scarp. However, no evidence of faulting, other than faint tonals, was observed in the Holocene(?) alluvium in any of the drainage crossings, either on the photos or in the field. A short tonal feature in a stream meander at the ranch house is visible on the U.S.D.A. photos, but has been obliterated by recent construction at the ranch. A field examination by this writer of the creek banks on the west side of Canada del Comasa on Barham Ranch failed to locate the fault, but some soil cover is present. An attitude of N85°W, 85°N was measured on a resistant strata in the Paso Robles Fm. a few meters south of the projected fault trace, and may suggest the approximate location of the fault.

At the southeast end of the well-defined surface segment, the fault should cross San Antonio Creek, but neither this writer nor Guptill and others (1981, p. 36-38) could find exposures of the fault in the 3-5 meter high stream bank of San Antonio Creek, or indications of faulting in the floodplain alluvium.

Guptill and others (1981), map the fault trace as extending southeastward from the main segment through Los Olivos to connect with the Baseline fault at State Highway 154 (see Figures 2 and 3). Evidence suggestive of a connecting reverse fault include the following data (see Figure 3):

1) The contact between the Paso Robles Fm. (Plio-Pleistocene) and Orcutt Sand (middle Pleistocene) is fairly linear, especially at U.S. Highway 101 (see Figure 3). In addition, the Paso Robles Fm. is topographically higher than the Orcutt Sand and is situated on the southeast side of the inferred fault; this relative position is consistant with reverse faulting, but does not require it.

2) A broad, southeast-trending, linear drainage at Los Olivos aligns with the Orcutt Sand-Paso Robles Fm. contact. As mapped by Guptill and others, the Orcutt Sand deposit southwest of the linear drainage is topographically higher than the Orcutt Sand deposit on the northeast side.

3) A low, southeast-trending swale in a late Pleistocene terrace unit parallels the inferred trace south of Los Olivos.

4) Two short breaks in slope and a short tonal occur in latest Pleistocene terrace deposits parallel to the inferred fault trace, between Baseline Avenue and State Highway 154 southeast of Los Olivos.

No evidence of faulting was seen in the latest Pleistocene to Holocene terrace deposits between Los Olivos and Baseline Avenue.

An examination was made of the air photos along the west end of the Baseline fault, although the fault is not evaluated in this report (see Bortugno, (1977). A broad, slightly-dissected, north-facing scarp in latest Pleistocene terrace deposits is clearly defined in the low-sun air photos, but is barely visible in the U.S.D.A. air photos. This low scarp extends westward from the fault trace mapped by Bortugno (1977) to immediately east of State Highway 154, and is shown by Guptill and others (1981, Figure 5). Although the scarp may be erosional, the low-sun air photos show two wet spots and a possible ground water barrier in the creek bed immediately east of where the scarp interests State Highway 154 (see Figure 3). Access to the property was denied by the owner.

The Los Alamos fault has been postulated by Guptill and others to have a western or northwestern extension west of Alisos Canyon Road: 1) westward along the south margin of Los Alamos Valley; and 2) northwest along U.S. Highway 101 to the Solomon Hills and Solomon Canyon. Air photo evidence permissive of reverse faulting along the south valley margin includes a weak alignment of features, including a landslide, low knolls in Paso Robles Fm. (Plio-Pleistocene), breaks in slope, faint tonals, and the starting point of headward erosion within a Holocene alluvial fan (see Figure 3). These surface features are discontinuous, but generally extend along the valley margin from Alisos Canyon Road to past Canada Laguna Seca. Air photo analysis of the northwestern extension shows a clear alignment of southwest-facing dip slopes in Paso Robles Fm. along the northeast side of U.S. Highway 101, but this orientation would not be formed by a southwest-dipping reverse fault, such as the Los Alamos fault. No other evidence permissive of faulting was seen on the air photos.

SEISMICITY

In 1902 and 1915, several damaging earthquakes occurred in or near Los Alamos Valley (Beal, 1915; Real and Toppozada, 1978; Toppozada, et al, 1978; Toppozada and Parke, 1982; Townley and Allen, 1939; Guptill and others, 1981). Magnitudes of the 1902 and the 1915 earthquakes were estimated to be Richter magnitude 5.5 (Toppozada and others, p. 14 and 17). Beal (1915) did an intensive field study immediately after the 11 January 1915 earthquake but did not observe surface deformation. A search of the numerous contemporary newspaper accounts (Appendix C of Guptill and others, 1981) yielded no statement of cracks, fissures, or displacement along the county road (presently U.S. Highway 101), the adjacent railroad, or at the Confaglia ranch.

A regional seismicity map for the period 1925-1978 is included in Figure 2 of Guptill and others (1981). Only one event appears near the Los Alamos fault, and the epicenter appears to be midway between Los Alamos and Los Olivos, where the southern extension would be located. Quality of the epicenter data is not known to this writer. Unpublished epicenter maps for the Santa Maria area (scale 1:250,000) were supplied by C. Real (CDMG). These maps, which utilize A-,B-, and C-quality data from the period 1969-1984, show a clustering of epicenters a few kilometers northeast of the Los Alamos fault.

CONCLUSIONS

Based upon an analysis of the available data described above, this writer's conclusions are as follows:

1. The main sement of the Los Alamos fault is reasonably well-defined by a northeast-facing scarp, linear drainages, and other features between Alisos Canyon Road and San Antonio Creek (Figure 3). Where trenched, the Los Alamos fault is a low-to moderate-angle, southwest- dipping reverse fault that displaces Paso Robles Formation, (Plio-Pleistocene), Orcutt Sand (middle Pleistocene), a late Pleistocene terrace unit, and overlying soils of probable Holocene age.

2. The age of most recent surface rupture is uncertain, as no ^{14}C age dates are available for the fault. Interpretations by different workers of soil descriptions in the trench logs yield estimated age dates for the youngest faulted soils of either latest Pleistocene to early Holocene (Guptill, p.c.,1985) or late Holocene (Borchardt, p.c., 1984).

3. The Los Alamos fault is not well-defined as a surface feature to the northwest and southeast of the main trace, although it may form the southwest flank of the Los Alamos syncline. The combined total length of the Los Alamos syncline, as mapped by Dibblee (1950) and Woodring and Bramlette (1950), is approximately 20 km. The length of the syncline, and historic seismicity in the Los Alamos area, suggest that the Los Alamos fault may extend well beyond the exposed surface trace as a subsurface feature.

4. Although not confirmed, the hypothesis of Sylvester and Darrow (1979) and Guptill and others (1981) for a southeast extension of the Los Alamos fault and connection with the Baseline fault is supported by the following data: a similar sense of displacement along the two faults; weak lineaments along the Paso Robles Fm. - Orcutt Sand contact northwest of Los Olivos; sparse surface features (tonals, breaks in slope) south and southeast of Los Olivos; and a west-trending scarp(?) in a latest Pleistocene terrace deposit located between the west end of the Baseline fault and Highway 154.

5. There is permissive, but weak, evidence of a western extension of the Los Alamos fault suggested by Guptill and others. This evidence includes the overturned, west-trending anticline mapped by Woodring and Bramlette immediately south of Los Alamos Valley, and, on the south margin of the valley, an alignment of low knolls and a landslide in Paso Robles Fm. with breaks in slope, faint tonals, and the starting point of headward erosion in a Holocene alluvial fan. The evidence of recent surface faulting is sparse, and the existence of a west-trending surface fault has not been adequately demonstrated.

6. No evidence of recent faulting was seen on the traces mapped in Canada Laguna Seca by Arnold and Anderson (1907) or by Woodring and Bramlette (1950). The faults could not be traced by this writer across the Holocene alluvium mapped by Guptill and others.

7. The hypothesis of Guptill and others (1981), of a northwest extension is supported by an alignment of dip slopes in the Paso Robles Fm. northwest of Los Alamos. However, the sense of displacement for fault rupture on the lineament would appear to be normal faulting (down to the southwest), which is the opposite of sense of displacement on the Los Alamos fault (reverse faulting, down to the northeast). In addition, cross-sections shown in Woodring and Bramlette (1950) indicate gentle folding of strata in the vicinity of the proposed northwest extension, instead of the tight compression shown along the main segment of the Los Alamos fault.

RECOMMENDATIONS

The trace of the Los Alamos fault shown highlighted in yellow on Figure 3 of this report meets the criteria of "sufficiently active and well defined" required for zoning. Therefore, zoning is recommended, based upon this report and the work of Guptill and others (1981). The other faults in Figures 2 and 3 (Woodring and Bramlette, 1950; Arnold and Anderson, 1907; Guptill and others, 1981) and in Sylvester and Darrow (1979), do not meet zoning criteria.

In light of the work by Guptill and others (1981) along the Baseline fault, the Baseline fault should be re-evaluated if time permits.

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Report reviewed; recommendations appear reasonable.
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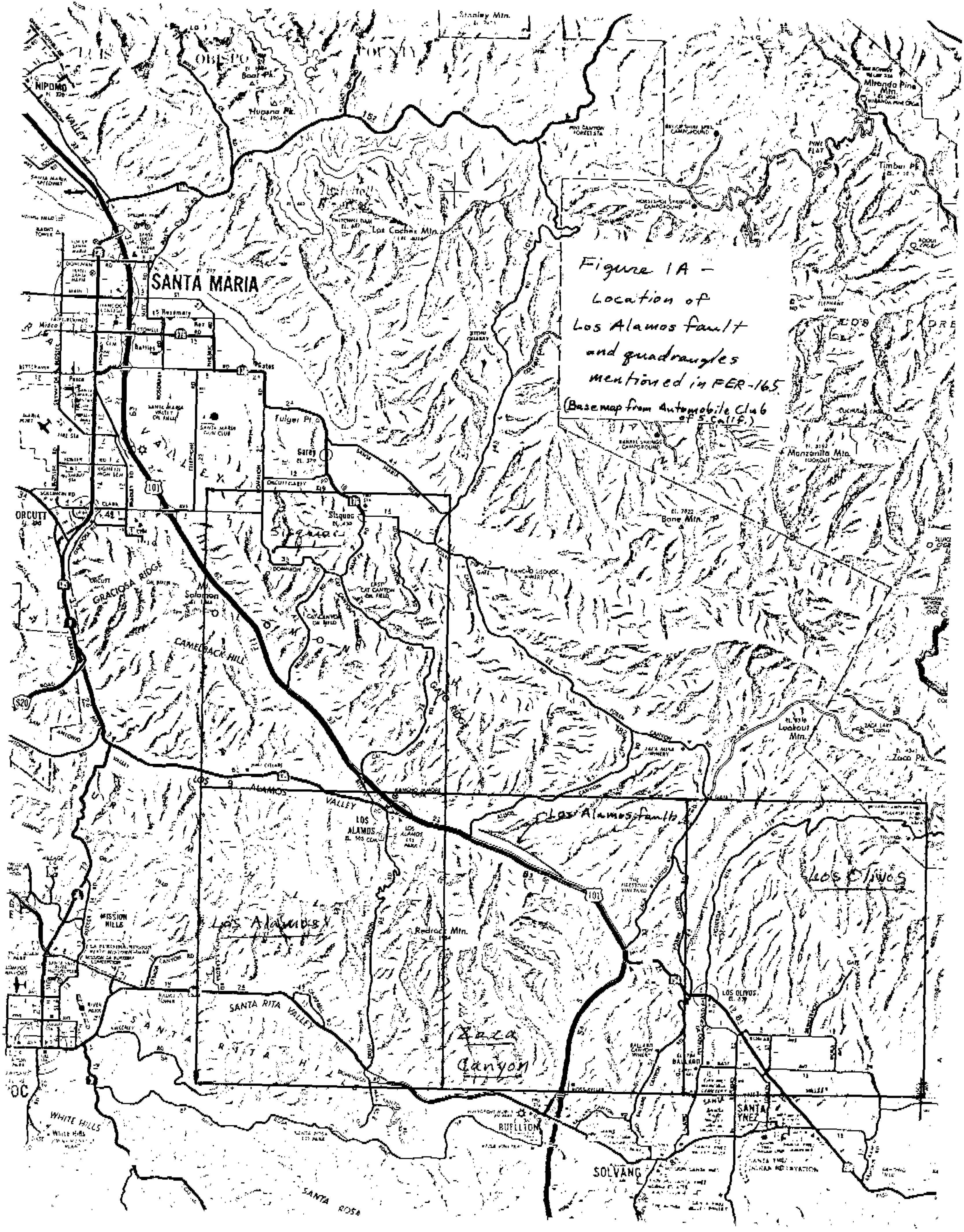

Figure 1A – Location of Los Alamos fault and quadrangles mentioned in FER-165

(Basemap from Automobile Club of S. Calif.)

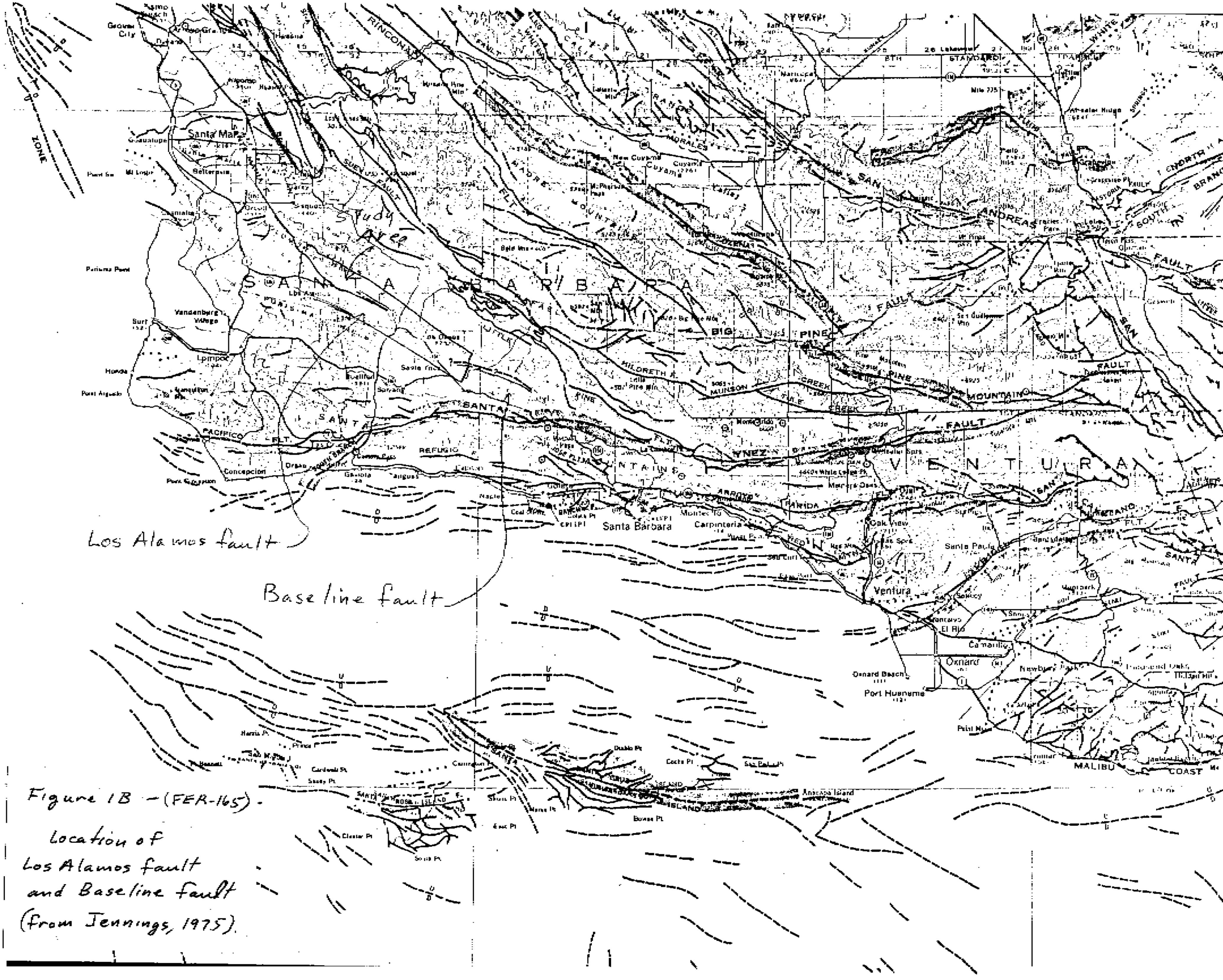

Figure 1B - (FER-165).

location of
Los Alamos fault
and Baseline fault
(from Jennings, 1975).